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RESEARCH ARTICLE

Market Perceptions and Opportunities for Native Plant Production on the Southern Colorado Plateau

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Abstract

Increases in revegetation activities have created a large demand for locally adapted native plant materials (NPM) in the southwestern United States. Currently, there is a minimal supply of local genotypes to meet this demand. We investigated the potential for the initiation of a native plant market in the southern Colorado Plateau. Through a literature search, interviews, and site visits, we identified existing native plant markets outside of the region as useful models to help initiate a regional market. We used web-based surveys to identify and analyze current and future NPM needs and concerns. Survey results indicate that management policy strongly drives decisions regarding the use and purchase of NPM. From a demand perspective, lack of availability and cost of NPM has kept purchasing minimal, despite policy changes favoring the use of natives. For suppliers, further development of NPM is limited by inconsistent and unreliable demand and lack of production knowledge. The knowledge and tools necessary to initiate an NPM market are available, but inadequate funding sources and insufficient information sharing hinder its development. Communication among producers, land managers, buyers, and researchers, as well as partnerships with local growers, appear to be vital to initiating a functional market.

Key words: local genotype, market perception differences, native plant market, native plant policy, web-based survey.

Introduction

Over the past century, in the Southwest, land use and management practices in conjunction with changing climate conditions have led to alteration of native ecosystems and a fire regime shift from frequent, low-intensity surface fires to large high-intensity crown fires (Covington & Moore 1994; Westerling et al. 2006). Many native species in southwestern *Pinus ponderosa* Dougl. ex Laws. (ponderosa pine) forests are well adapted to periodic drought and fires of low intensity (Hunter & Omi 2006). However, drought conditions and wildfires are projected to increase in the region (McKenzie et al. 2004; Westerling et al. 2006; Seager et al. 2007). As a result, prolonged drought stress and a changing fire regime may have direct effects on local plant community composition and structure (Hanson & Weltzin 2000; Wang & Kemball 2005; Hunter & Omi 2006). In light of these concerns, interest in restoring these disturbed lands has become more widespread (Allen et al. 2002; McKay et al. 2005).

In recent years with major fires such as the 2000 Cerro Grande and the 2002 Rodeo-Chediski, wildfires have arguably become the primary driver of restoration and rehabilitation efforts in the Southwest (Friederici 2003). Land management agencies such as the U.S. Forest Service (USFS) and U.S. Bureau of Land Management (BLM) are required to prescribe emergency watershed-rehabilitation measures when and where deemed necessary to: (1) stabilize soil; (2) control water, sediment, and debris movement; (3) prevent ecosystem degradation; and (4) minimize threats to human life or property. Among post-fire rehabilitation treatments, grass seeding is the most commonly used and cost-effective method to stabilize soils and establish ground cover for erosion control (Richards et al. 1998; Robichaud et al. 2000; Beyers 2004; Wolfson & Sieg in press) on firelines and hillslope areas determined to require protection.

In Arizona and New Mexico, both the area burned by wildfire and the funding allocated for post-fire seeding have increased dramatically in the last 30 years (Wolfson & Sieg in press, Fig. 1). Regionally, seed used for post-fire seeding has shifted from mixes dominated by perennial non-native species to mixes incorporating more native species (Wolfson & Sieg in press), although non-natives are still used. Beyond post-wildfire rehabilitation, revegetation is an integral component of other land management practices in the region including

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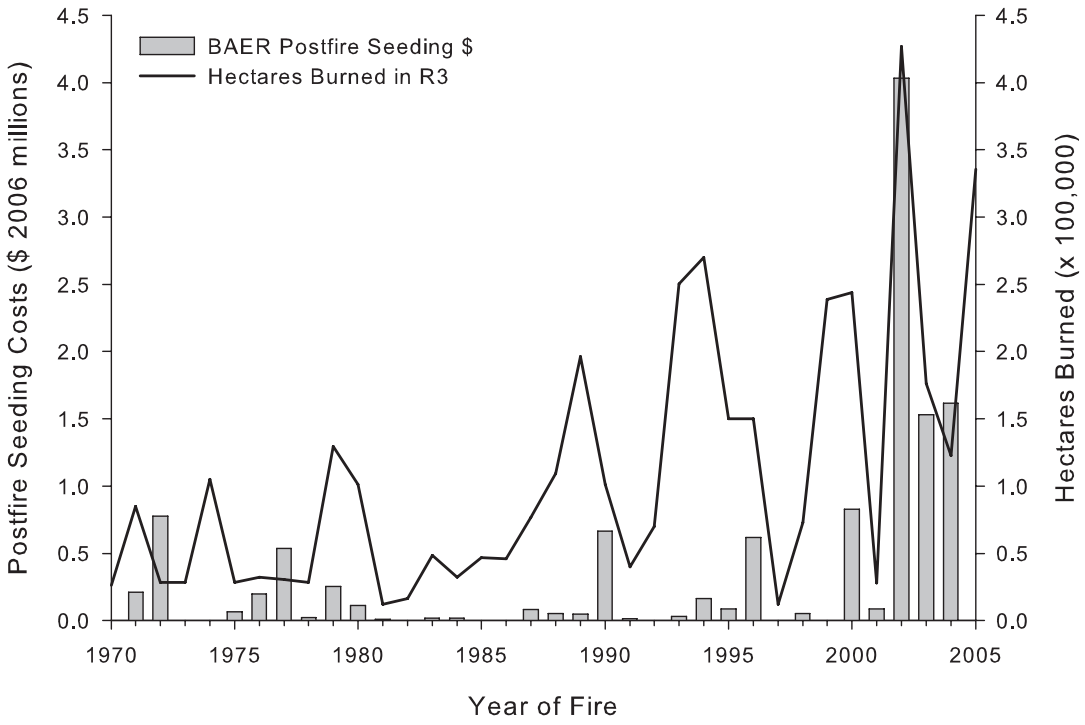

Figure 1. Spending on seeds purchased for post-fire rehabilitation (bars) in USDA FS Region 3 (AZ and NM) BAER projects between 1971 and 2005 (Wolfson & Sieg in press) compared with the total hectares burned (line) on all federally administered lands in AZ and NM from 1971 to 2005 (Sackett et al. 1994; Swetnam & Betancourt 1998; Snider et al. 2003; SWCC 2009).

invasive species management, livestock grazing, wildlife habitat management, roadside rehabilitation, mine reclamation, and recreational use.

Within the last 30 years, revegetation policies have increasingly stressed using native plant materials (NPM), and more recently, recognized the importance of using locally adapted NPM during restoration and rehabilitation activities (Richards et al. 1998; Erickson 2008). However, although national policies for federal land management agencies such as the USFS and BLM direct the use of native plant species as a first choice in revegetation activities, non-native species may be used when using native species is deemed impractical (Richards et al. 1998; Soller 2003; Beyers 2004); for example, in emergency conditions to protect resource values or when NPM are not available or economically feasible (Erickson 2008). Consequently, non-native species continue to be used in revegetation projects throughout the region, often due to the increasing need for post-fire emergency rehabilitation in conjunction with the lack of availability and high cost of NPM (Wolfson & Sieg, in press) that are locally adapted and genetically compatible with existing plant populations (Rogers & Montalvo 2004) (hereafter "local genotypes").

New revegetation policies and funding sources have emerged as a result of increased recognition from Congress of the need for an abundant supply of NPM and the establishment of the Federal Interagency NPM Development Committee in 2000 (USDA & USDI 2002). Since 2000, interagency projects have been developed to meet the need for increased NPM availability and production information (Pellant et al. 2004; Shaw et al. 2005). Unfortunately, only minimal efforts currently exist in the Southwest and, due to the lack of local genotypes available, federal, state, tribal, nonprofit, and private entities presently purchase restoration materials from distant sources. Thus, regional projects continually incorporate non-local genetic materials which may be more susceptible to the negative effects of changing environments (Huenneke 1991; Schmid 1994; Rogers & Montalvo 2004) and threaten the long-term sustainability of restored sites (Lynch 1991; Hufford & Mazer 2003), as well as other local populations (Linhart 1995; Montalvo & Ellstrand 2001) with which they may interbreed.

With NPM production efforts currently established in surrounding regions, increased policy recognizing the value of using NPM, and needs for locally adapted plant supplies, market opportunities exist that may directly benefit the southern Colorado Plateau's diverse ecosystems. This study addresses the following four questions: (1) Could native plant markets outside of the region serve as models to guide the development of an NPM market in the region? (2) What role does current policy play on the use and demand for NPM? (3) What are the needs and concerns of both supply and demand stakeholders involved with NPM? (4) What factors limit the initiation of an NPM market in the southern Colorado Plateau?

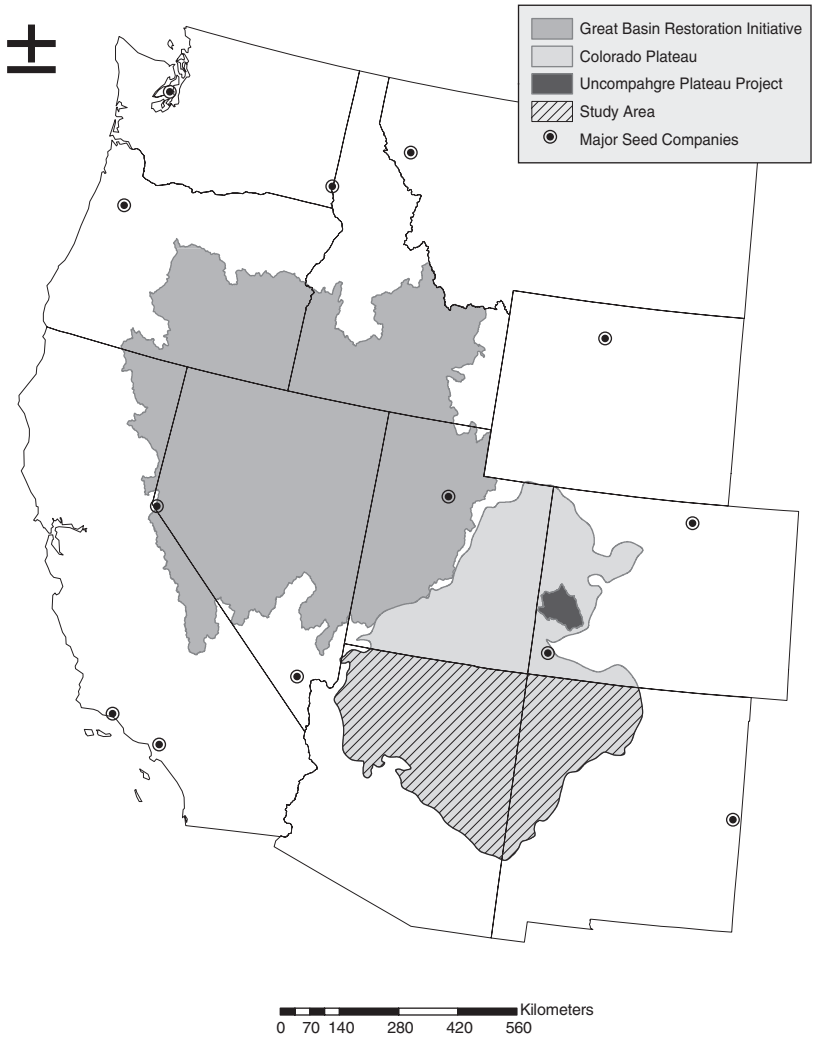

Figure 2. Current cooperatives and major seed suppliers within the Colorado Plateau and other nearby regions.

Methods

This study assesses the opportunity to initiate a native plant and seed industry in the southern Colorado Plateau (Fig. 2). To explore market development methodologies and perceptions, we investigated existing native plant markets and administered web-based surveys to natural resource professionals and selected seed companies in the southern Colorado Plateau and in nearby regions.

To identify potential models which could be used to help guide the development of a regionally based NPM market, we reviewed current literature including scientific articles, unpublished theses and reports, and government documents. We then interviewed natural resource professionals within the region to gain further insight on markets previously identified. The most relevant markets were selected based on their similarity to the southern Colorado Plateau's size and market demands.

We developed two distinct web-based surveys to assess current native plant market perceptions. A demand survey was administered to a target group of individuals from federal, state, private, and nonprofit entities who were actively involved in restoration in the region (Table 1(a)). A supply survey was administered to a targeted group of individuals from both large- and small-scale seed production companies in Arizona, New Mexico, nearby western and Great Plains states, and other successful seed production companies (Table 1(b)). Complete details on the survey methodology are available from the authors.

We developed 42 questions for the demand survey and 37 questions for the supply survey based on preliminary information from interviews and current literature (Richards et al. 1998; Hooper 2003; Soller 2003). Each survey question was arranged into a series of related survey questions and placed within five thematic areas pertaining to NPM: (1) policy and regulation; (2) issues and concerns; (3) future use and

Table 1. Total number of survey participants by market type: (a) total number of potential demand respondents in all of Arizona and New Mexico by agency type and (b) total number and location of potential commercial seed company respondents.

(a) *Agency Type*	*Number of Demand Participants*
Federal	21
State	8
Nonprofit	7
Private	3
Tribal	3
Total	42
(b) *State*	*Number of Supply Participants*
Arizona	4
California	4
Colorado	7
New Mexico	4
Utah	5
Other	15
Total	39

needs; (4) purchasing and expenditures; and (5) collaboration and funding. We created and administered finalized surveys (42 demand and 39 supply) online (Andrews et al. 2003; Kaplowitz et al. 2004; Ryu et al. 2005) using the web tool SurveyMonkey (www.surveymonkey.com).

Analysis of final survey response datasets was completed using Statistical Package for the Social Sciences (SPSS) software (SPSS 2007). We calculated survey answer frequencies (n) and valid percents of respondent participation for each question. Survey responses "Don't know" and "Decline to answer" are not included in the valid percent calculations. For questions that offered multiple responses, total percentages may exceed 100. Percents are rounded, which may cause totals to be slightly greater or less than 100%.

Results

Model Markets

We identified the BLM Great Basin Restoration Initiative's (GBRI) Great Basin Native Plant Selection and Increase Project (GB Project), and the Uncompahgre Plateau Project's Native Plant Program (UP Project) as useful models for guiding the development of a native plant market in the southern Colorado Plateau. Within their respective regions, these projects have helped to increase the supply of NPM for restoration practices through multi-organizational collaborations and partnerships with private growers (Pellant et al. 2004; U.S. GAO 2008*a*). Funding provided to the projects is used, in part, to conduct research on key native plant species to develop critical production methodologies and seed sources. Research results and information are then transferred to growers and land managers. In addition, growers are given an opportunity to participate in buy-back programs, which aim to encourage suppliers to grow native species not yet marketed (Shaw et al. 2005; UP Project 2007). Under the buy-back program, minimal amounts of stock seed, along with associated production information is provided to growers under an agreement that the projects will buy back a small portion of the seed produced for distribution to additional growers or in some cases to provide NPM for research needs. Meanwhile, growers are given a chance to sell the additional seed produced on the open market.

Within the Great Basin, market demands are primarily driven by needs of government agencies for post-fire rehabilitation and restoration (GBRI 2001). Funded entirely through the BLM GBRI, total 5-year funding for the GB Project was approximately \$4.5–6 million between 2001 and 2006 (GBRI 2001; Pellant 2006). On the Uncompahgre Plateau, although market demands are driven by private and public land needs for habitat improvement, NPM production focuses on providing local-source seed for government agency use. The UP Project, which was modeled after the GB Project, has a separate nonprofit management group as well as a formalized Memorandum of Understanding (MOU) with the BLM, USFS, and the Colorado Division of Wildlife which allows the group to receive both direct and in-kind funding from federal, state, private, and nonprofit entities (U.S. GAO 2008*a*). Additional funding provides financial support to local growers for producing NPM. Between 2002 and 2007, the program received approximately \$2.4 million in funding, with the majority coming from the BLM (50%) and the USFS (35%) (UP Project 2007). Based on annual operating costs for both the GB and UP Projects, the estimated cost for collection, research, increase, and release is approximately \$15,000–25,000 per species annually and requires approximately 4–12 years to develop a species (CPNPI 2007).

Survey

We received 37 completed demand (88% response rate) and 33 completed supply (85% response rate) surveys from the targeted sample group. Due to nonrandom sample selection and a small sample size (demand survey $n = 42$ and supply survey $n = 39$), extrapolation of results and conclusions to a larger population should be considered cautiously (Babbie 2004); however, an effort was made to include all involved stakeholders.

The majority of demand survey respondents were employed by "federal" or "state" agencies (47 and 27%, respectively), and currently implemented seeding as a management practice (83%). Of supply survey respondents, 94% were currently involved in selling NPM of which the majority (97%) sold either "native seed" solely (32%) or NPM and non-native seed (65%).

Native Plant Policy and Regulation. Demand respondents indicated that "organization policy" (25%) followed by "availability of native seed" (21%) were the most important factors influencing the purchase of native seed. The majority (80%) of respondents' organizations or agencies currently required the use of certified native seed; seed meeting certification

procedures which provide verification of source, genetic identity, and genetic purity of wildland collected or field grown plant germplasm materials (AOSCA 2003). For those organizations or agencies that did not currently require the use of certified native seed, 67% of the respondents anticipated requirements to do so within the next 5 years.

Native Plant Material Concerns. The majority of all respondents (65%) found defining the term "local genotype" difficult and suggested the definition is species specific and highly dependent upon topography, elevation, and climatic conditions within a region. In follow-up questions, an overwhelming majority of buyers (93%) indicated that their organization was concerned about the genetic source of native seed; yet 41% of respondents used non-native seeds in restoration efforts. Half of demand respondents agreed "lack of availability" was the primary limiting factor preventing their organization from buying local seeds and "availability" (27%) along with the "cost" (22%) of seed were the greatest obstacles to overcome in order to initiate a successful NPM market in the southern Colorado Plateau (Fig. 3a). The majority of buyers (87%) foresaw a need for local genotypes for seeding practices within the next 5 years.

Producing local genotypes was "somewhat" (47%) or "very important" (33%) to suppliers and the majority (70%) agreed that there is a current market for local genotypes used in large-scale restoration projects. However, suppliers commented that supplying local genotypes is difficult due to the costs and limited resources available during the wildland seed harvesting and agricultural seed production process. In addition, growers were more interested in supplying seed that is currently in large demand. Furthermore, from the supply perspective, the "lack of consistent and reliable demand" (38%), and "knowledge of native plant production" (21%) were the most significant limitations to supplying NPM (Fig. 3b).

Native Plant Material Use and Needs. Of demand respondents who currently seed, just over one-quarter (26%) primarily apply seed for "ecological restoration," while "wildlife habitat improvement" and "burned area rehabilitation" were close seconds (22% each, Fig. 3c). When demand respondents were asked about the five most desirable species to be brought into commercial production (n = 149), respondents selected in order of highest demand (23% of the total responses): *Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths (blue grama), *Festuca arizonica* Vasey

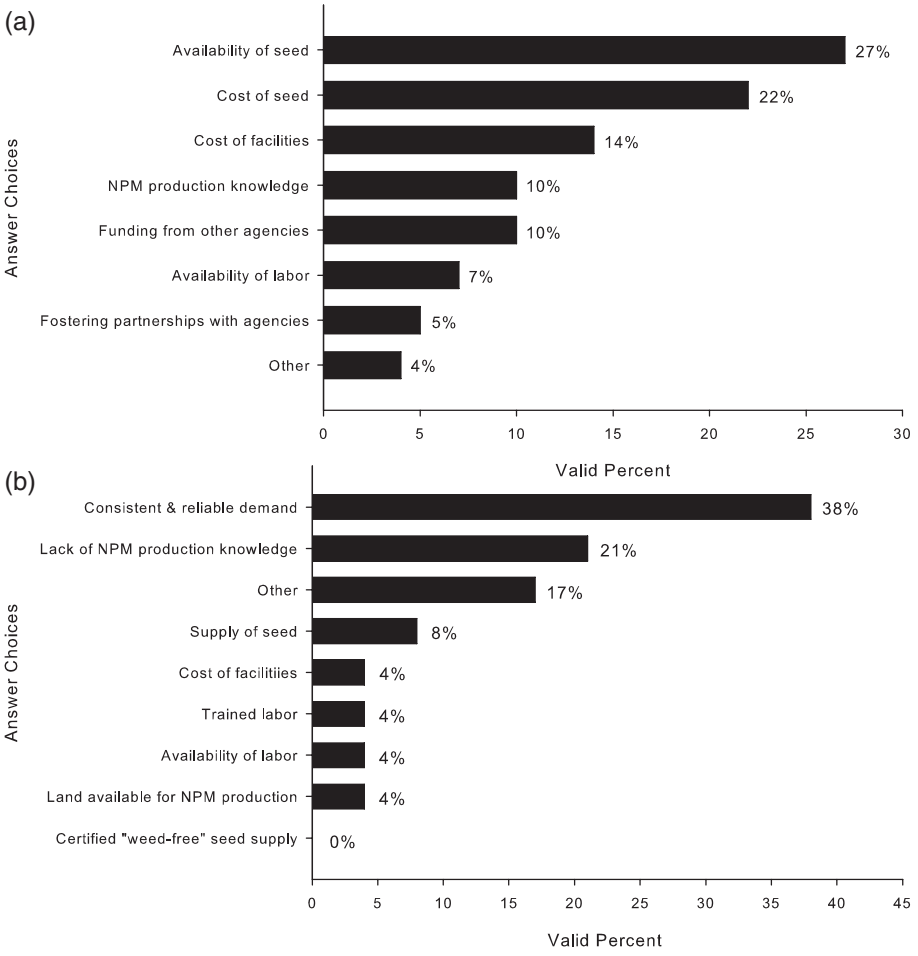

Figure 3. Continued.

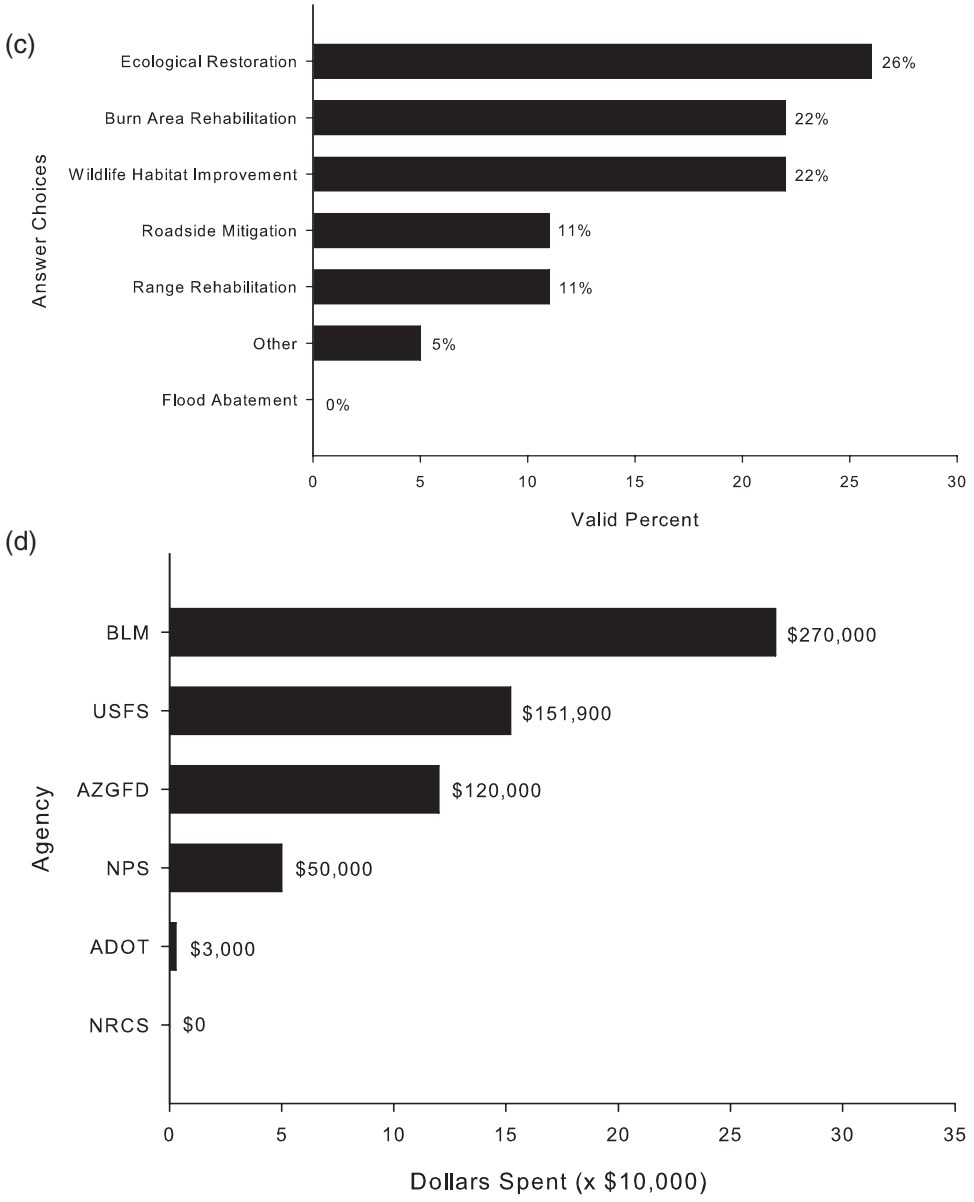

Figure 3. Results of web-based surveys by survey question: (a) greatest obstacles to overcome in order to initiate a successful NPM market in the southern Colorado Plateau according to those in demand of NPM, (b) most significant limitations to a business involved in the production of NPM, (c) primary land management practices those in demand of native seed implement seeding for, and (d) dollars spent in 2006 on NPM by agency type.

(Arizona fescue), *Elymus elymoides* (Raf.) Swezey (squirreltail), *Atriplex canescens* (Pursh) Nutt. (fourwing saltbush), and *Poa fendleriana* (Steud.) Vasey (muttongrass). In contrast, among all responses from suppliers (n = 53), the five species for seeds in highest demand (19% of the total responses), in order of frequency were: *Pseudoroegneria spicata* (Pursh) A. Löve (bluebunch wheatgrass), *Achnatherum hymenoides* (Roem. & Schult.) Barkworth (Indian ricegrass), *Pascopyrum smithii* (Rydb.) A. Löve (western wheatgrass), *Elymus lanceolatus* (Scribn. & J.G. Sm.) Gould (thickspike wheatgrass), and *Elymus elymoides*. Overall, seed of grass species was in highest demand by both demand and supply respondents, but only *Elymus elymoides* was listed among the top five by both groups; this difference in plant lists was a direct result of buyers and suppliers being surveyed in different geographic areas.

Native Plant Material Purchasing and Expenditures. The BLM spent the most on NPM in 2006, followed by the USFS (Fig. 3d). In 2006, the top two management activities for which native seed was purchased included "burned area rehabilitation" and "ecological restoration." However, 61% of all the native seed purchased was for burned area rehabilitation

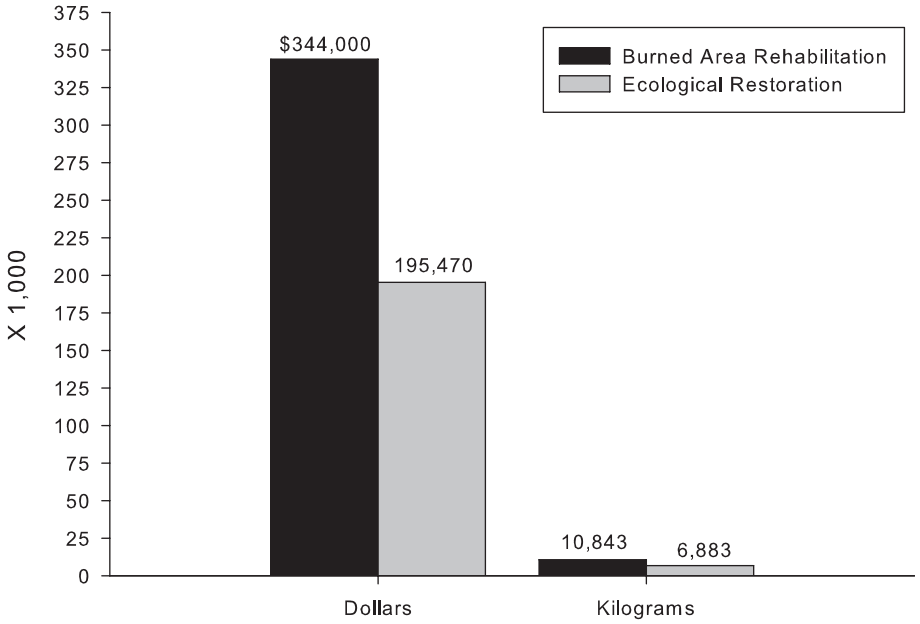

Figure 4. Quantity (kg) of native seed purchased versus dollars (United States) spent on native seed in 2006 for ecological restoration and burned area rehabilitation.

activities (10,843 kg), amounting to 42% of the overall expenditures on native seed in 2006 ($344,000, Fig. 4). According to the demand survey, almost half (44%) of respondents' native seed supply came from out-of-state sources within the same ecological region in which the rehabilitation or restoration was conducted (e.g., Great Basin, Colorado Plateau, etc.)

Collaboration and Funding. Among buyers, collaboration occurred most often between "federal" (22%) and "state" agencies (20%). Over one-half (57%) of buyers currently received "federal" or "state" monies or incentives to assist with seeding practices. Most suppliers' (62%) current native plant operations are supported internally, while one-third (33%) are supported by both internal and external funding.

Discussion

Market models and survey results revealed that many factors limit an NPM market in the southern Colorado Plateau, including the need for: (1) stronger collaboration among federal, state, private, and nonprofit entities; (2) increased communication among seed producers, land managers, buyers, and researchers; (3) funding mechanisms for development of local genotype plant materials; (4) an agreement regarding the scale of "local genotypes"; (5) increased availability and reduced costs of local genotypes; and (6) native plant market stability.

The GB and UP Projects are useful models in guiding development of an NPM market in the southern Colorado Plateau. These projects provide a framework of how factors related to limited collaboration, insufficient funding, and lack of communication can be overcome. It appears that multiagency collaboration can be used to acquire long-term funding sources needed to increase NPM development. These models suggest that between $2.4 and $6 million over a 5-year period is needed to initiate a similar project in the southern Colorado Plateau (GBRI 2001; Pellant 2006; UP Project 2007).

Partnerships between government agencies and private growers appear to be essential as improved information sharing and buy-back options give growers tools and incentives needed to enhance development of NPM. Beyond buy-back options, stewardship contracting, available through the BLM and USFS, authorizes these agencies to enter into long-term agreements (up to 10 years) with communities, private sectors, and others to meet land management objectives associated with improving forest and rangeland health while benefiting communities (U.S. GAO 2008*b*). Indefinite-delivery/indefinite-quantity contracts (which agree to award payment upon completion of specified tasks in a fixed period of time) have also been used by the BLM and USFS in several western states to produce required quantities of seed from specific areas for planned projects (Erickson 2008; 2009, USDA Forest Service, personal communication). Utilizing contracting options provided through the USFS and BLM would further encourage market development.

Our survey indicates that policy strongly influences agency decisions regarding NPM use. Due in part to difficulties interpreting current native plant policy and economic constraints, federal policy on use of NPM has been implemented erratically (Richards et al. 1998) and in the southern Colorado Plateau, lack of availability and high costs of local genotypes have made existing native plant policies moot, thereby allowing the continued use of non-native species (Wolfson & Sieg in press). Stronger and more consistent policies for their use

(Richards et al. 1998) could enhance the regions' NPM market potential by helping to increase their demand. For example, implementation of stronger native plant policies has stimulated the development of new certified seed categories that accommodate the use of native plant germplasm (Jones & Young 2005). According to current literature (Loftin 2004; Jones & Young 2005), many states have adopted seed certification policies specifically accommodating NPM and, because of this, suppliers now offer certified native seed as the demand for it has increased.

According to the survey, the genetic source of seed appears to be a concern for land managers and seed companies, yet an inconsistent demand and lack of reliable production knowledge make suppliers hesitant in furthering the development of local genotype plant materials. These issues are further complicated by difficulties in determining what constitutes a "local genotype" (Mortlock 1999; Burton & Burton 2002; Williams & Price 2002) as well as by varying requests for species, types of genetic materials, and amounts needed. Confusion over these issues creates dilemmas for suppliers when faced with deciding on what types and how much material to produce and market (Hooper 2003). Determining target species, finding common ground on the genetic classification of local plant materials, and consolidating NPM requests are critical first steps to effectively build a regional NPM market and developing local genotype plant materials.

One approach to the "local genotype" scale issue is to delineate seed transfer zones based upon geographic and elevational boundaries in which plant materials can be transferred with little risk of being poorly adapted (Mahalovich & McArthur 2004; Aubry et al. 2005). Forested areas of Arizona and New Mexico are already divided into 10 physiographic-climatic tree seed zones (Schubert & Pitcher 1973), which could be used as surrogates for grass seed transfer zones (Soller 2003). Consistent funding for research and development will be needed to enable completion of research projects exploring the basic genetic information for determining appropriate seed collection zones.

According to the survey, suppliers appear to lack the knowledge necessary to successfully produce NPM. Over the years a wealth of information has been accumulated regarding NPM production. Within the region, increased information transfer regarding available production guidelines (Potts et al. 2002) would further encourage potential suppliers to grow needed NPM. Greater information sharing may also help to lower NPM costs by providing suppliers with cost-effective production techniques. Minimal research may be needed to develop production guidelines for regionally specific species for which information is not available.

According to our survey results, focusing on grass seed production will be important during the market initiation phase. Demand for grass species is promising as the majority of research on NPM production has focused on development of grass species (Robichaud et al. 2000). Many of the desirable grass species identified are readily available through commercial seed producers outside the region. Therefore, focusing on producing and marketing locally collected and grown grass species (e.g. specialty market) could alleviate competition pressure from non-regional suppliers.

Table 2. Total number of hectares seeded by year in USFS BAER Region 3 (AZ and NM) from 1990 to 2005 and 2000 to 2005 (adapted from data by Wolfson & Sieg in press).

Year	*Total Hectares Seeded*
1990	7,733
1991	192
1992	0
1993	648
1994	1,945
1995	769
1996	7,993
1997	0
1998	607
1999	0
2000	16,020
2001	1,039
2002	29,634
2003	9,293
2004	16,199
2005	4
Avg. 1990–2005	5,755
Avg. 2000–2005	12,031

Specialty NPM markets have been assessed in Nevada and created in Utah. In 2005, the Nevada Wildland Seed Producers Association requested a feasibility study to evaluate the potential for a native plant and seed market, as well as interests in forming a cooperative among Nevada NPM producers (Curtis et al. 2005). Within this cooperative, 30 producers each invest approximately $5,000 and obtain additional funding through credit or loan options to finance the cooperative start-up cost. Profits are made by marketing locally developed, certified, and labeled "Nevada Grown" materials. This study estimated total operational expenses at approximately $6 million annually. Utah Intermountain Native Plant Growers Association produced a similar market for "Utah Choice" NPM (Meyer 2005). The Nevada and Utah NPM markets appear to be primarily supported by demand for NPM for fire prevention and rehabilitation efforts (Curtis et al. 2005; Meyer 2005).

Burned area rehabilitation plays a large role in the demand for and purchase of NPM in the southern Colorado Plateau, specifically grasses used for post-fire seeding (Beyers 2004; Wolfson & Sieg in press). Our survey indicates that the BLM followed by the USFS purchase the majority of the seed in the region and according to agency policy the use of native species is preferred (USDA & USDI 2002). The total burned area that has been seeded within USFS Region 3 has increased annually since 1990 (Table 2). Assuming that policies continue to favor seeding following disturbance, a future native plant market may continue to be driven by federal government demand for post-fire seeding materials, and more specifically those which are native.

The variable demand for NPM results from unpredictable fire frequency and size (Richards et al. 1998; USDA & USDI 2002; Jones & Young 2005). The unpredictability of fires from

year to year can cause high demands for large quantities of native grass seed at short notice, and often at a time when NPM supplies are low (Dunne & Dunne 2003). In turn this forces buyers to purchase materials from outside the region (Curtis et al. 2005) at high costs (Dunne & Dunne 2003). Increasing the region's storage capacity (USDA & USDI 2002; Soller 2003) may be one way to address issues of on-demand availability and alleviate high market prices often associated with native seed in short supply (Jones & Young 2005). Adequate long-term seed storage facilities would allow for seed to be purchased and stored in favorable seed production years (USDA & USDI 2002; Williams & Price 2002; Soller 2003). This would stabilize availability during unfavorable seasons (Mortlock 1998) or in heavy fire years. However, suppliers answering the survey stressed that providing NPM for an unreliable market is often infeasible and that it is more profitable to produce and sell NPM which have the highest consistent demand. Moreover, suppliers surveyed expressed that lack of funding is a major obstacle in providing native seed, which is often limited due to the greater costs associated with collecting and producing it (Mortlock 1998; Burton & Burton 2002). Forms of contracting may be necessary to assure growers that the seed they produce will be purchased and, in some instances, provide them with seed stock accompanied by associated production information. A synergistic approach of increasing storage capacity while offering suppliers market incentives may provide an effective mechanism to increase the supply of needed NPM within the region.

What is Needed for Market Initiation?

A diverse approach is needed to overcome the many challenges of initiating an NPM market in the southern Colorado Plateau. Based on the GB Project and the UP Project, greater collaboration, funding opportunities, and communication are essential to increasing NPM. Because of the large role that policy plays in agencies' decisions regarding when and where to use and purchase NPM, stronger policies and support from federal and state governments (Mortlock 1998) will be needed to help increase supplies and lower cost of local genotype plant materials.

There is an apparent disconnect between market perceptions among buyers and producers. It is clear that for a market to be developed, an integrated collaborative strategy is needed among producers, land managers, government agencies, organizations, and researchers at both local and regional scales. Collaborative efforts should focus on developing a guiding framework to address these primary issues (Williams & Price 2002): (1) increasing communication among stakeholders; (2) increasing genetic research for the development of appropriate seed zones; (3) increasing information transfer regarding reliable methods for producing NPM; (4) finding the most effective methods to improve market stability; and (5) securing a stable funding mechanism for market initiation and continued research and development. Obtaining appropriate long-term funding may be the most critical factor to overcome to initiate a regional market.

Two main investment structures could be used for market initiation within the region, a purely government funded approach, or a collaborative effort between government agencies and private entities. The GB Project is strictly government funded and demand is primarily driven by multiple government agency needs. The GB Project uses its funding to conduct extensive research on key native plant species. The production information obtained together with a small quantity of seed stock is then provided to growers along with a buy-back option as a market incentive. Only a minimal amount of seed is bought back, leaving the rest of the supply to become available for sale on the open market. The cost estimate needed to initiate a market under this scenario is between $4.6 and 6 million over a 5-year period (GBRI 2001; Pellant 2006). The UP Project exemplifies government and private funding. Demand is driven by both private and public land NPM needs, with a focus on providing a local-source of seed for agency use. Major funding is secured through government agencies, and additional outside funding is obtained to provide financial support and buy-back options to local growers. An estimated $2.4 million of government funding over a 5-year period would be needed under this scenario (UP Project 2007).

An entirely privately funded market initiation approach is most likely infeasible due to the substantial initial investment needed. Based on survey results, the southern Colorado Plateau market is primarily driven by government needs. This suggests that all, or at least half, of the funding should come from government agencies and primarily those responsible for burned area rehabilitation seeding activities.

Burned area rehabilitation plays a central role in the demand for NPM in the southern Colorado Plateau. A determination of how much seed is needed to meet post-fire seeding demands will be important to accurately assess the feasibility of market initiation. We produced a theoretical example to determine an estimated annual budget for post-burn seeding efforts in the region. Between 1990 and 2005, the USFS typically seeded ca. 5,700 ha/year (Wolfson & Sieg in press). Based upon our survey results of area seeded, we assume that the BLM seeds about the same area as the USFS, and that all other agencies combined seed about half this area. Cumulatively, we estimate that approximately 14,250 ha are seeded annually in Arizona and New Mexico as part of burned rehabilitation efforts. This would require an annual investment of $373,000 from government agencies, and roughly 183 ha of production area from seed companies (Table 3). Assuming a 20% fluctuation between mild and severe fire seasons, between 11,400 and 17,000 ha could require seeding in Arizona and New Mexico annually. This would require between $297,000 and $444,000 annually from government agencies, and between 146 and 218 production hectares from seed companies.

We based estimates on the average yield and maturity of production fields for the top eight grass species in demand (from survey results) in weighted-ranked order (varying weight given to species based on ranking order) and the burned hectares seeded per year (Wolfson & Sieg in press) while assuming the average percent seed viability/species

Table 3. Estimated total production hectares and government investment needed to supply the southern Colorado Plateau with enough seed to meet post-fire seeding demands (ha) during an average fire year.

Top Eight Species in Highest Demand (Next 5 Years)	*Avg. Yield (kg/ha)*[a]	*Seeds/kg*[b]	*Production Hectares*	*Viability*[c]	*Commercial Price/kg*[d]	*Discount*	*Total Investment*	*Avg. Wildfire Seeding Rate PLS/m²*	*Hectares Seeded*
Bouteloua gracilis (blue grama)	157	1,818,823	47	0.87	$26.46	50%	$84,119	600	4,761
Festuca arizonica (Arizona fescue)	224	1,212,549	30	0.97	$26.46	50%	$86,131	600	3,250
Bouteloua curtipendula (side-oats grama)	157	421,085	24	0.90	$30.86	50%	$53,178	600	597
Achnatherum hymenoides (Indian ricegrass)	392	310,853	24	0.93	$44.09	50%	$196,254	600	1,139
Poa fendleriana (muttongrass)	39	1,962,124	21	0.85	$198.42	50%	$69,710	600	568
Elymus elymoides (squirreltail)	224	423,290	14	0.90	$88.19	50%	$128,260	600	507
Distichlis spicata (inland saltgrass)	168	1,146,410	11	0.92	$110.23	50%	$94,550	600	810
Sporobolus airoides (alkali sacaton)	168	3,858,110	11	0.90	$39.68	50%	$33,298	600	2,665
Interested membership							50.00%		
Total			183				$372,751		14,298

Estimates and assumptions for this table are referenced in the Discussion section.
[a] USDA Forest Service Fire Effects Information System (USFS 2008) and NRCS Plant Guides (NRCS 2008).
[b] Granite Seed website (www.graniteseed.com).
[c] Damon Winter, Granite Seed, personal communication.
[d] Western Native Seed (www.westernnativeseed.com).

(85–97%, Damon Winter, Granite Seed, personal communication), roughly a 50% discount to federal agencies that purchase native seed in bulk or through a competitive bidding process (Curtis et al. 2005), and an average wildfire seeding rate of 600 pure live seeds per square meter (PLS/m^2, Hunter et al. 2006). The species used in this scenario are not a recommended list of species but act as a single example for determining the financial investment needed based on an NPM market driven by fire rehabilitation efforts. For rehabilitation efforts to be successful, using materials that are genetically diverse should be a priority. Furthermore, this hypothetical example varies substantially from figures estimated from the GB and UP Project. Because of this, a thorough economic analysis will be needed to determine actual market expenditures.

Concerns over the effects increased disturbance will have on native plant communities (Huenneke 1991) underscores the importance of using both locally adapted and genetically diverse plant materials to maintain the genetic integrity of ecosystems. Therefore, the development of any NPM market should not be viewed as a financial burden, but rather an ecological investment necessary for the future stability and adaptability of ecosystems' native plant communities. Although this paper is regionally focused, it builds on information gained from similar studies worldwide (Mortlock 1999; Burton & Burton 2002; Williams & Price 2002), and provides additional insight into issues and attitudes of those involved in an NPM industry. There is reason to believe that restoration practitioners as well as land managers will utilize our study to expand upon the findings we have presented here, in order to overcome challenges that may directly affect the development and continuation of the NPM industry worldwide.

Implications for Practice

- Policy strongly favors the use of NPM for rehabilitation, but low supply and inconsistent demand in the southern Colorado Plateau have created an inefficient circle resulting in minimal NPM availability and use.
- Development of NPM is hindered by a lack of adequate resources for buyers to consistently purchase the quantities necessary to make supplying these materials profitable and available.
- Several models for native plant propagation exist in surrounding regions: public, public–private, and private enterprises. Seeding needs and cost projections in the southern Colorado Plateau suggest that a viable native plant production enterprise could support regional demand at an annual investment of around $373,000 (United States).

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